Determination of the neutron reflection coefficient as a function of reflector material

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Abstract

This work presents a simple method for determination of the neutron reflection coefficient (n) as a function of different neutron reflector materials.A laboratory neutron source (Am-Be) with activity of 16 ci is employed with a (BF_3) neutron detector. Am-BeThree types of reflector materials are used as samples, the thickness of each sample is (5cm).

It is found that (η) is: -

For polyethlyene = 0.818
For iron = 0.056
For lead = 0.044

Introduction

Neutron reflection method shows good application for many purposes like moisture and oil content measurements, as well as to determine the hydrogen content in hydrocarbons and the ratios of carbon to hydrogen content in different matrices. It is usefull to present a simple method for determination of the neutron reflection coefficient (η) as a function of different neutron reflector materials.

Theory

The slowing down of fast neutrons is due mainly to the elastic scattering collision between the neutrons and the nuclei of the target [1]. In this type of interaction, the kinetic energy is conserved and the energy level of the target nucleus is the same before and after collision [2]. The neutron strikes the nucleus, which is almost always in its ground state, the neutron reappears, and the nucleus is left in its ground state. The neutron in this case is said to have been elastically scattered by the nucleus. In the notation of nuclear reactions, this interaction is abbreviated by the symbol (n, n)[3].

By applying the principle of conservation of momentum and energy it is possible to derive a relationship for the minimum energy (E_{min}) of a neutron after a collision depends on the mass of the target nucleus (A) given by [1] :-

$$E_{min} = \left[\frac{A-1}{A+1}\right]^2 E \quad \ldots\ldots\ldots\ldots (1)$$

Where A is almost exactly the mass number, and E is the energy of the neutron before collision. Polyethylene is frequently used as a moderator where it is desired to slow fast neutrons down to thermal energies for experimentation. In these applications,

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it is highly desirable to maximize the hydrogen content and minimize any impurities - especially those that might absorb neutrons. For neutrons with kinetic energy between (1 keV)and (20 MeV) the hydrogen elastic scattering cros - section is currently the most accurately known of all standards [4] .
The method for the determination of hydrogen content in various samples by neutron reflection and absorption is based mainly on measuring the thermal neutron flux arisen in the bulk material surrounding a fast neutron source. As it can be seen in figure (1), the neutrons emitted by a laboratory source have energies far above the thermal range. The neutrons loss energy due to the elastic collisions with the nuclei of media in which the source is placed [5]. The average energy loss per collision is given by [6]: -

$$\overline{\Delta E} = \frac{E}{2}\left[1-\left(\frac{A-1}{A+1}\right)^2\right] \quad \ldots\ldots\ldots\ldots (2)$$

Where E is the neutron energy before collision, and A is the mass number.
The neutron reflection coefficient (η) is calculated through the equation [7]: -

$$\eta = \frac{I - I_0}{\rho I_0} \quad \ldots\ldots\ldots\ldots (3)$$

Where I and I_0 are the counting rates of neutrons with and without sample , ρis the density of the reflector material .

Experiment

A laboratory isotopic neutron source (16Ci-AmBe) is employed with (BF_3) neutron detector. A cadmium sheet of (Imm) thickness is located between the neutron source and the detector in order to exhaust the incident thermal neutrons coming directly from the neutron source (i.e. (0.5 mm - 1 mm) thickness is a filter which is passed by neutrons only at energies above (0.5 eV) [8]. Three types of neutron reflector material (i.e. polyethylene, iron, and lead) were employed as samples each of (5cm) thickness. Figure (2) shows the experimental set up of the used technique.

Results and Discussion

The neutron reflection coefficient (η) as a function of reflector material shows different values at about (5 cm) of reflector thickness as shown in table (1). Its found that the values of (η) are: (0.818, 0.056 and 0.044) for polyethylene, iron, and lead) respectively.
This simple method can be used also as a neutron moisture gauge in measurements on soils, building materials in civil engineering, agriculture, hydrology and well loging. The advantage of the neutron method is that it is non destructive, non contacting, rapid, repeated measurements can be made in situ, and the measurement integrates over a large volume of the medium or sample. The latest is especially important, because it is possible to get an accurate moisture determination only by integrating over a large volume of soils and many industrial materials with heterogeneous moisture distribution.

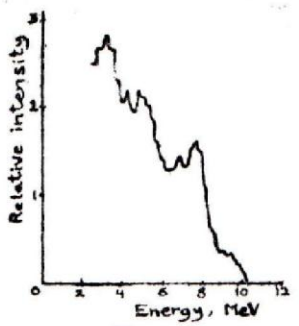

Table [1] Determined values of the reflection coefficient (η)

Element	Thickness (Cm)	Density (ρ) (gm/cm^3)	Reflection coefficient (η)	$\rho\eta$
CH_2	5	0.93	0.818	0.761
Fe	5	7.86	0.056	0.440
Pb	5	11.35	0.044	0.499

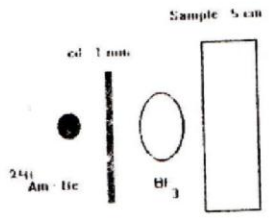

Fig. 2.Representation of the experimental setup

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تحديد معامل انعكاس النيوترونات كدالة لمادة العاكس

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الخلاصة

يقدم هذا البحث طريقة مبسطة لتحديد معامل انعكاس النيوترونات (n) كدالة للمادة في عدة مواد عاكسة للنيوترونات. استخدام مصدر نيوتروني مختبري نوع (Am-Be) ذي الفعالية 16 ci مع كاشف نوع (BF_3) وثلاثة أنواع من المواد العاكسة للنيوترونات التي استخدمت كنماذج وكان سمك كل نموذج (5 سم) . وقد وجدت قيمة معامل انعكاس النيوترونات (η) للمواد وكما يلي :

للبولي اثيلين = 0.818

للحديد = 0.056

للرصاص = 0.044